Resistance heating

The present invention relates to a tool in a packaging machine, which comprises as heating element a first shaped article, preferably a plate, with at least one electrically conductive track of any desired length. The present invention further relates to a method of heating the tools or the film in a thermoforming or sealing station of a packaging machine.

These days, foodstuffs are increasingly offered for sale in plastics packaging. Such plastics packaging consists as a rule of a packaging tray, thermoformed from a plastics film web, and a lid, which is sealed onto the packaging tray after the latter has been filled with the product to be packaged, for example foodstuffs.

Prior to thermoforming and during sealing, the packaging film has to be heated. This heating is currently performed predominantly with heating cartridges, which are for example inserted, preferably pressed, into bores in the sealing tool and thus heat said tool. These heating cartridges have the disadvantages, however, that the bores have to be produced very precisely, that the input of thermal energy takes places locally, which leads to an uneven, as a rule undesirable, temperature distribution in the part to be heated, that failure of a heating cartridge often goes unnoticed and that removal of the heating cartridges is virtually impossible. Moreover, the heating cartridges exhibit a high heat capacity, such that the heating cartridges continue to heat for a long time even after they have been switched off and temperature peaks of up to 800°C occur locally in the heating cartridge.

The object is therefore to provide a tool in a packaging machine which does not exhibit the disadvantages of the prior art and which therefore exhibits a temperature distribution which is as precisely adjustable as possible and optionally very homogeneous as well as having rapid response behaviour and therefore a short post-heating time, failure of a heating circuit being detectable and the tool being at the same time cheap and easy to assemble and disassemble.

The object is achieved according to the invention with a tool which comprises as its heating element a first shaped article, preferably a plate, with at least one electrically conductive track of any desired length, wherein the first shaped article is arranged, preferably clamped, between a second shaped article and a third shaped article, which are both preferably plates, wherein the second shaped article is a working tool, in particular a sealing frame, a thermoforming mould or a heating plate and wherein the material, the geometry and/or the arrangement of the electrically conductive track is so selected that any desired temperature distribution may be achieved in the second shaped article.

According to the invention, the first shaped article comprises an electrically conductive track, which is preferably applied to, particularly preferably printed or etched on, the surface thereof or which is likewise preferably embedded in, for example laminated into, the first shaped article. The person skilled in the art will understand that the track may be applied onto or into the

first shaped article in any desired manner which permanently ensures the desired arrangement of the track.

According to the invention, the track exhibits any desired length, wherein the material of the track is preferably copper, stainless steel and/or aluminium.

The first shaped article exhibits any desired shape or size and is of any desired thickness. For example, it may be a sheet, film or coating with a thickness in the range from preferably 0.1 - 3000 µm, which is deposited on or applied to another shaped article, for example, and on or in which the track is arranged.

The cross section of the track preferably varies in accordance with the desired temperature profile, wherein a small cross section results in a relatively high temperature and a large cross section in a relatively low temperature. According to the invention, the track is arranged on or in the first shaped article in any desired pattern, wherein it never intersects itself, however. This pattern is preferably so selected that the track is distributed as uniformly as possible on or in the shaped article, so making it possible to achieve a very homogeneous temperature distribution. It is likewise preferable for the pattern to be so arranged that areas of the shaped article exhibit a higher track density than others, whereby the temperature in the areas of greater density is higher than in the areas of lower density while cross-section and material remain the same.

Clamping of the heating element between the second and third shaped articles makes possible easy exchange of the

heating element. The person skilled in the art will understand that, any other means of connection, for example adhesion, is also suitable provided it ensures precise positioning of the heating element in the tool between the second and third shaped articles. Clamping of the heating element advantageously offers the possibility of disassembly, however, for example so that a heating element may likewise be exchanged when a tool is being changed.

The electrically conductive track and the object to be heated are preferably in as direct contact with one another as possible. It is therefore advantageous for the first shaped article to be arranged between the second shaped article and the third shaped article. Said arrangement and clamping result in a small distance between the first shaped article and the second shaped article small. In a further, likewise preferred embodiment, the first shaped article and the second shaped article are connected irreversibly together, wherein the second shaped article is a working tool, for example a sealing frame or a heating plate. This means that the distance between the working tool to be heated and the heat conductor is minimal. The first shaped article and therefore likewise the electrically conductive track are then preferably conformed in shape to the second shaped article, i.e. the thermoforming mould or sealing tool.

In a particularly preferred embodiment, the first shaped article is a plate, however, so making it easy to produce.

It is also preferable for the first shaped article to comprise a plurality of electrically conductive tracks,

which are arranged next to and/or above one another and are supplied jointly or separately with voltage.

The electrically conductive tracks may be arranged nested in one another, such that a plurality of tracks determine the temperature distribution of one area, or the electrically conductive tracks may be restricted to areas, such that the constitution and wiring of one track determines the temperature distribution solely of one area. These arrangements may also be combined with one another.

With the same material, geometry and arrangement, an increase in the voltage leads to an increased heating power and therefore to higher temperatures, such that the number of possible temperature distributions is increased considerably, in particular if each individual track is supplied separately with voltage.

The width of the track preferably amounts to between 0.3 and 30 mm, particularly preferably between 0.4 and 3 mm and very particularly preferably 0.45 and 2 mm. The height of the tracks preferably amounts to 0.09 - 3 mm, particularly preferably 0.3 -0.7 mm. Both the width of a track and its height may vary along the track, whereby the temperature advantageously varies along the track. For example, the temperature along the track may vary due to a change in the cross-section of the track in the area of the seal seam, in such a way that the seal seam is separable in a desired area while it is not separable in another desired area. The temperature in the area of smaller cross-section is higher at the same voltage and with the same material, and the seam produced is not separable, than in the area of larger cross section, in which the seam produced is separable.

The present invention further provides a tool which comprises as its heating element a first shaped article, preferably a plate, with at least one electrically conductive track of any desired length, wherein the first shaped article is arranged, preferably clamped, between a second shaped article and a third shaped article, which are both preferably plates, wherein the second shaped article is a working tool, in particular a sealing frame, a thermoforming mould or a heating plate and wherein the electrically conductive tracks, which are arranged next to and/or above one another, are supplied with voltage separately from one another in such a way that any desired temperature distribution may be achieved in the second shaped article.

In the case of separate voltage supply, for example due to each track having its own heating transformer, the heating power of each individual track is substantially proportional to the voltage applied, such that a different voltage applied to a track leads to a different temperature distribution. In this way, the tool may be adapted very simply, without resetting, to modified tool or packaging characteristics.

Each of the electrically conductive tracks is preferably individually controllable. In this way, the temperature distribution may be varied in many different ways, even during the course of the process. For example, each track may have its own controllable voltage supply. Since the material and cross-section of a track does not change during the course of a process, the temperature output is increased if the voltage is raised. In addition, the

temperature distribution may be varied by switching individual tracks on or off. Failure of each individual track is electronically measurable.

In a preferred embodiment, the tool comprises one or more temperature sensors. In this way, temperature distribution may be measured and specifically controlled during the process. In this way, it is advantageously possible to safeguard against excessive temperatures. The temperature sensors are preferably incorporated into the first shaped article.

The statements made below apply to both subject matters of the invention.

The distance between the turns of the electrically conductive track or between two electrically conductive tracks is preferably < 6 mm, particularly preferably < 4 mm, so allowing a very homogeneous temperature distribution.

In a particularly preferred embodiment, the heating element is a printed circuit board. The board consists of an electrically nonconductive material, to which one or more tracks have been applied, which are capable of individual electrical activation. The material of the track is preferably copper or aluminium, the thickness of the printed circuit board amounts preferably to 0.5 mm to 1 mm and the track height preferably amounts to 0.09 - 0.5 mm. The small track height makes it possible to achieve good thermal homogeneity over the entire heated surface area, the risk of overheating being slight. The track may be applied to the printed circuit board in a manner known to

the person skilled in the art , thus for example by printing or etching. The heating element is very good value and readily exchangeable and has a long service life. The printed circuit board may also be of multilayer construction, such that a plurality of tracks are arranged one above the other and may be switched on or off and controlled optionally independently of one another.

In a further preferred embodiment, the heating element is a heating film. This embodiment also exhibits a particularly long service life and a low weight. The tracks of heating films are likewise thin and flat, such that good thermal homogeneity may also be achieved with heating films and the risk of overheating is likewise low. In addition, the response behaviour and thus the post-heating time of a heating element of this embodiment is particularly short, since heating films exhibit a low intrinsic mass and therefore their heat capacity and/or their heat transmission resistance is low.

The person skilled in the art will understand that the first shaped article is either made from a material with a high electrical resistance, for example from ceramic material or a heat-resistant film, or the electrically conductive track is covered in an insulating material, for example a plastics or a ceramic paper, or that the first shaped article is coated with a material with a high electrical resistance.

An electrically insulating layer is preferably arranged between the first shaped article and the second shaped article, such that short-circuiting between parts of the track and the second shaped article is reliably prevented.

The insulating material is preferably hard anodised aluminium with a layer thickness of < 100 µm, particularly preferably < 50 µm. Very particularly preferably, the insulating material is applied to the second shaped article.

The third shaped article preferably comprises heat insulation or consists of a heat-insulating material, such that the heat is advantageously emitted towards the second shaped article, i.e. to the film or packaging being processed.

In a preferred embodiment, a resilient layer is additionally arranged between the third shaped article and the first shaped article, said layer consisting for example of glass fabric or silicone rubber, or the third shaped article consists of a resilient material. The first shaped article may be so braced together with the second and the third shaped article by the resilient layer that contact between the first shaped article and the other two shaped articles is ensured throughout. In particular, therefore, no air is trapped between the first shaped article and the second shaped article, such that the heating power of the first shaped article is ideally emitted to the second shaped article.

The second shaped article preferably consists substantially of aluminium or an aluminium alloy, since it has good thermal conductivity in this embodiment. In a likewise preferred embodiment, the second shaped article also comprises a plurality of materials of different thermal conductivities, in order further to assist in the desired temperature distribution.

The tool is preferably designed for low voltage, such that the VDE guidelines for protective low voltages are met. The operating voltage particularly preferably amounts to < 80 V, very particularly preferably to < 60 and most preferably to < 45 V. The tool is therefore a low-cost tool.

The heating element is preferably connected to the tool by means of electrical connection components, for example by plug-in connections or by means of terminals. However, a non-detachable connection, effected for example by soldering, is also feasible. A detachable connection, for example of the plug-in or terminal type, is preferred, however, because assembly or disassembly and exchange of the heating element are thereby made simple and quick. The connecting lines may be also be produced on the heating element by (pre)fabrication, so simplifying manufacture and assembly or disassembly of the tool still further.

In a preferred embodiment, the tool comprises at least one first shaped article and a plurality of second shaped articles. In this way, a plurality of different packages in any desired formats may thereby be processed simultaneously, wherein the temperature distribution for each of the packages may be different and may also be capable of variation in different ways during the course of the process as a result of separate control of each individual track. Even where the tool is provided with just one track, variable temperature distribution may be achieved by using different materials, changes in cross-section and variable arrangement of the track over each individual package. Variation of the temperature

distribution during the course of the process is also possible, by controlling the supply voltage for example.

In a preferred embodiment, the tool comprises at least one track per second shaped article. In this way, the temperature distribution may be individually adjusted for each package and may be different for each package. Failure of a track may be directly identified. Providing every second shaped article with at least one temperature probe makes it possible specifically to control the temperature distribution for each package.

A possible embodiment is also provided by arranging a plurality of first shaped articles in the tool. The first and second shaped articles optionally correspond to one another. However, it is preferable, for example in the case of a change of format or of packaging size, only to replace the second shaped article(s) and to adapt the first shaped article(s) by reprogramming the control system.

The person skilled in the art will recognise that the tool according to the invention may be used at any desired location in the packaging machine. However, it is preferably part of a thermoforming or sealing station or a film preheating zone.

The tool according to the invention has the advantage of being very simple and cheap to produce. The temperature distribution may be adjusted in many different ways by the arrangement of the track(s) on and/or in the first shaped article, by the material and/or cross section of the track(s) and control of the electrical voltage. The tool is simple to assemble and may be simple exchanged. The failure

of one or more tracks may be detected very quickly and simply. Response behaviour is quick and therefore the post-heating time of the tool is short. It is particularly suitable for heating the tools or film in a thermoforming or sealing station of a packaging machine.

The present invention therefore further provides a method of heating the tools or the film in a thermoforming or sealing station of a packaging machine using the tool according to the invention, in which an electrical voltage is applied to the track of the first shaped article. The temperature distribution in the tool is thus very variable and may be very precisely adjusted.

In the case of sealing, for example, the track may be arranged with a high turn density in the area of the seal seam, such that the temperature in the area of the seal seam is very high while according to the invention the package contents are not exposed to any elevated temperature. Or the material, geometry and/or arrangement of the track in a thermoforming machine may for example be such that the areas in which the packaging film is more severely stretched are heated to a greater extent than the areas in which the packaging film is not stretched or is stretched only slightly. By changing the supply voltage to the tracks, the temperature distribution may be further adapted, even during the course of the process.

The voltage preferably amounts to < 70 V. A tool design for low voltages is therefore sufficient, which saves on cost.

The heating power is preferably controlled with an impulse welding controller by measuring the heat conductor

resistance and/or with a temperature sensor. The temperature distribution of the tool may thereby be varied specifically even during the course of the process.

The method is simple and cheap to perform and allows, where necessary, very precisely adjustable temperature distribution and variation even during the course of the process.

The present invention further provides a method of resetting a tool for a packaging machine, in which control of the temperature distribution of the heat conductor of the tool is reprogrammed and then the second shaped article(s) of the tool is/are optionally exchanged. This method is simple and cheap to perform and allows very quick adaptation of a packaging machine, for example in the case of changes of format or changes to the packages.

The invention is explained below with reference to **Figures 1-4**. These explanations are given merely by way of example and do not restrict the general concept of the invention.

Figure 1 shows a packaging machine

Figure 2 shows an embodiment of the tool according to the invention

Figure 3 is a perspective view of a further tool according to the invention

Figure 4 shows an embodiment of the tool according to the invention for the simultaneous production of 16 packages.

In **Figure 1** a top web 40 is reeled off a supply reel 41 and guided over deflection pulleys 42 to the individual working stations. The top web 40 is conveyed along over a chain conveyor 43, which conveys the top web 40 in the direction of arrow 44. A bottom web 45 is conveyed from a supply reel 46 by a chain conveyor 48 driven via the chain wheels 47 in the direction of arrow 49. The bottom web 45 is guided over a table 50 comprising a cooling plate and an insertion template. The package contents 51 are then laid on the moving bottom web 45 and conveyed with it in the conveying direction 49 to the further working stations. Bottom web 45 and top web 40 are brought together after placing of the package contents 51 on the bottom web 45, once the top web 40 has passed through a preheating station 52. The webs 40, 45 lying on one another pass together with the package contents 51 through the vacuum chamber 53, which consists of a stationary bottom part and a lowerable top part. When the package contents 51 and the webs 40, 45 pass into the vacuum chamber 53 and the vacuum chamber 53 is closed, the top web 40 is held taut over the package contents 51 in the manner of a tent. After closure of the vacuum chamber 53, the air is sucked out of the stationary bottom part and thus also from around the package contents 51. After evacuation, a sealing plate is pressed against a sealing device (not shown) by means of hydraulic or pneumatic apparatus, for example by compressed air cushions. The sealed vacuum package then leaves the vacuum chamber 53 and is conveyed over a cooling plate to the cutting means 54.

Figure 2 shows a tool according to the invention, in the present case a heating plate, such as is used for example in the thermoforming station (not shown in Figure 1), the

preheating zone 52 and/or the sealing zone. The tool, in the present case a heating plate, comprises a first shaped article 1, a plastics plate with elevated electrical resistance. Located on the plastics plate is a track 2, which is distributed as evenly as possible over the entire plastics plate. The track 2 has a width of 2 mm. The distance 4 between the individual turns of the track 2 amounts in each case to 4 mm, whereby the temperature distribution of the tool is highly homogeneous. The track 2 comprises an electrical connection 9,10 at each of its ends, with which it is connected to a voltage source (not shown). The connection to the electrical voltage source is symbolised by the pressure contact 11. The plastics plate 1 is clamped between a second shaped article 5, in this case an aluminium plate, and a third shaped article 6, in this case a heat-insulating plate, wherein a resilient layer of silicone rubber 8 is additionally arranged between the plastics plate 1 and the heat-insulating plate 6. The person skilled in the art will recognise that the shaped articles 1, 5 and 6 do not have to be plate-shaped and that the second shaped article 5 may for example also be a thermoforming or sealing mould. The aluminium plates 5 and the heat-insulating plate 6 are screwed together with the screws 13 in such a way that the plastics plate 1 is clamped therebetween. A 50 µm thick electrically insulating layer 7 of hard anodised aluminium is also arranged between the track 2 and the aluminium plate 5 in order to prevent short-circuiting of the track 2 through the aluminium plate 5. The thickness of the aluminium plate 5 is 10 mm. In operation, the temperature differences at the underside 12 of the aluminium plate 5 are less than 1°C even under full load.

The shaped articles 1, 5 and 6 and the layers 7, 8 may comprise holes, so that a reduced pressure may be applied. This embodiment of the tool according to the invention is of particular interest when the second shaped article 5 is not an aluminium plate but rather a thermoforming mould.

The temperature is controlled either via an impulse welding controller by measuring the heat conductor resistance and/or with a temperature sensor (for example a PT 100) and a thermostat from M.K. Juchheim, Moltkestraße 13 - 31, D-36039 Fulda or Sika Struthweg 7-9, D-34260 Kaufungen.

The operating voltage of the heating element is approx. 60 V, with earthed centre on a transformer, such that only approx. 30 V arises as the highest voltage between the track 2 and the aluminium plate 1. The transformer is connected via a transformer switching relay TSRLF made by FSM Elektronik GmbH, Kirchzarten, Germany. The switching relay is the subject matter of European Patent EP 0 575 715 B1, which is introduced herein by way of reference and thus constitutes part of the disclosure.

Figure 3 shows a perspective view of a further tool according to the invention. The heating element comprises a plurality of first shaped articles 1, in this case printed circuit boards, which comprise at least one track, a plurality of second shaped articles 5, in this case moulds for sealing packaging, and a third shaped article 6, which is a heat-insulating resilient layer, and is clamped to the rear wall 14 by means of screws. In order to ensure uniform clamping of the printed circuit board 1 between the heat-insulating resilient layer 6 and the moulds for sealing 5, the screws are passed through a spacer sleeve 13 and

screwed into the rear wall 14. The spacer sleeve 13 ensures that the distance between the rear wall 14 and the moulds for sealing 5 is substantially the same throughout and therefore the printed circuit board 1 is pressed uniformly against the moulds for sealing 5. Between the printed circuit board 1 and the moulds for sealing packaging 5 there is located an electrically insulating layer 7, which ensures that no short-circuiting occurs between the tracks of the printed circuit board 1 and the moulds for sealing 5. Electrical connection is effected by means of terminals and/or plugging the cabling into the plug connector 9 provided therefor, which is firmly connected to the printed circuit board 1, for example by means of a soldered joint. Since each mould for sealing packaging 5 comprises a corresponding printed circuit board 1 and its own electrical connection 9 for voltage supply and control and at least one temperature sensor (not visible here), the temperature distribution of each mould for sealing packaging 5 may be individually and specifically controlled. In addition, failure of a track is recorded simply and directly.

Figure 4 shows an embodiment of the tool according to the invention for simultaneous production of 12 packages, in this case for example for preheating the packages. Here too, the tool comprises the first shaped article 1, in this case a heating film, the second shaped articles 5, in this case aluminium plates, and the third shaped article 6, which is a heat-insulating layer, wherein the heating film 1 is located between the aluminium plates 5 and the heat-insulating layer 6 and is braced together with a rear wall 14. The heating film 1 comprises a large number of electrically conductive tracks (not visible here), which

may be supplied with voltage together or separately. In addition, a plurality of temperature sensors are incorporated into the tool, preferably at least one per package. In this way, the temperature distribution of each aluminium plate 5 is in itself specifically controllable and this tool simultaneously applies different temperatures to packages.

List of reference numerals:

1	First shaped article
2	Electrically conductive track
3	Width of track
4	Distance between the turns of the track/between two tracks
5	Second shaped article, for example aluminium plate, thermoforming or sealing mould
6	Third shaped article, for example heat-insulating plate
7	Electrically insulating layer, for example silicone rubber
8	Resilient layer
9	Electrical connection
10	Electrical connection
11	Connection to the electrical voltage source, pressure contact
12	Underside of aluminium plate
13	Screws, spacer sleeve for screws
14	Rear wall
40	Top web
41	Supply reel for top web
42	Deflection pulleys
43	Chain conveyor, top web
44	Conveying direction of top web
45	Bottom web
46	Supply reel for bottom web
47	Chain wheels
48	Chain conveyor, bottom web
49	Conveying direction of bottom web, conveying direction
50	Table with cooling plate and insertion template
51	Package contents

52 Preheating station

53 Vacuum chamber

54 Cutting means